The effects of mainstem flow and water velocity on salmon populations of the Columbia River - Additional Information on Summer Migrants

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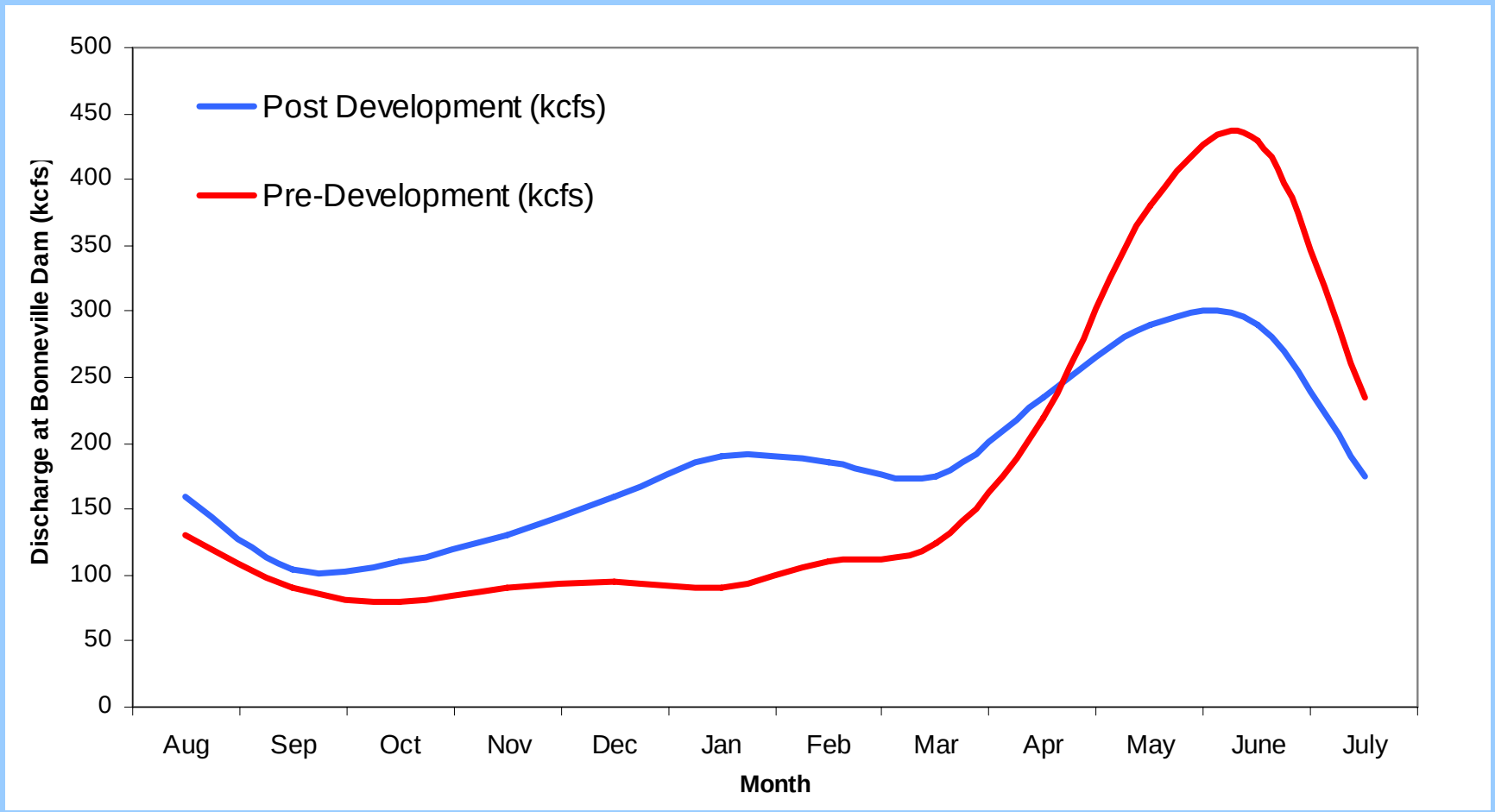
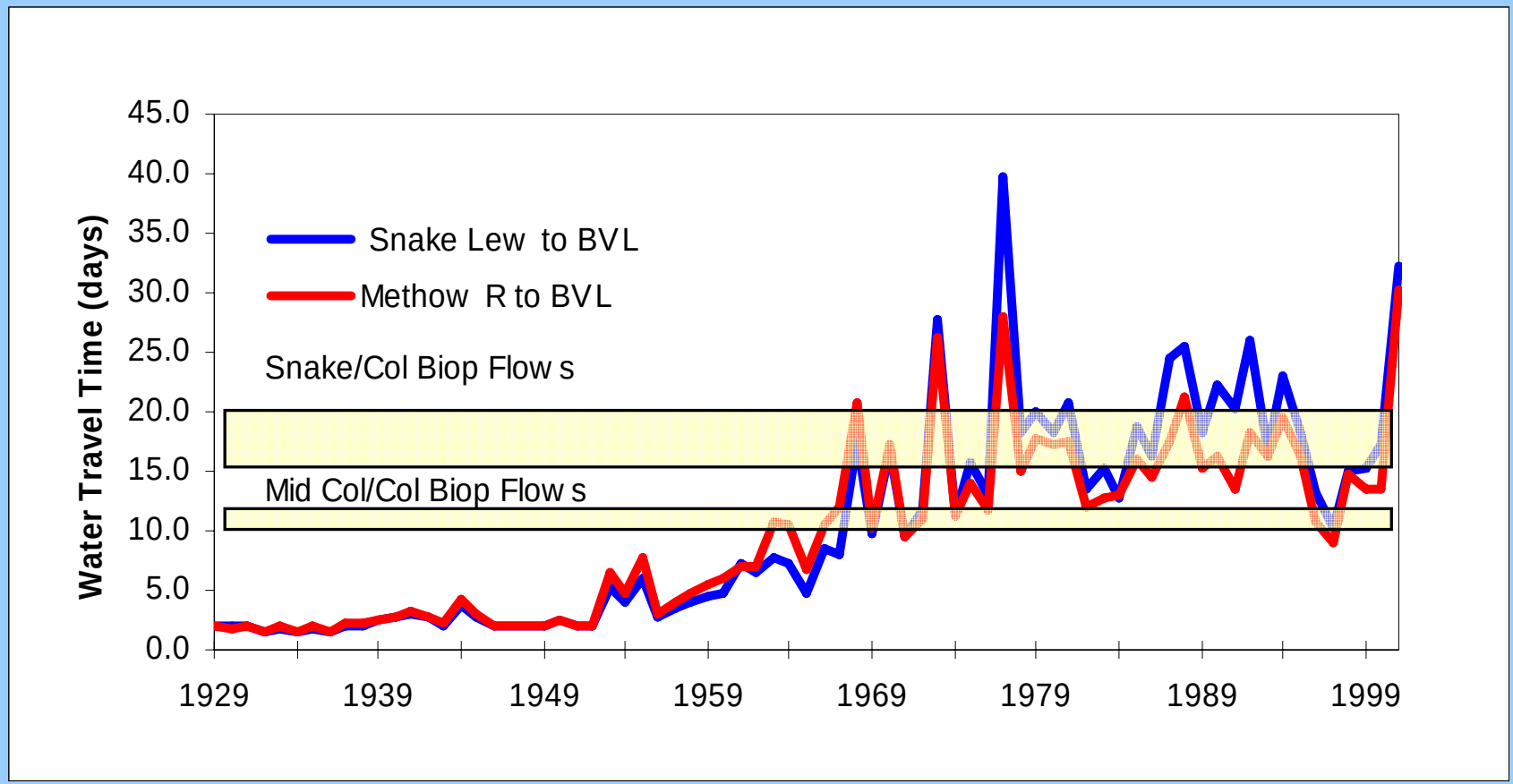
Objectives

- Historical Perspective
- Scientific weight of evidence approach to evaluate flow-temperature/survival relation
  - Mechanisms
  - Multiple data sets
  - Multiple life history stages
- Analysis of smolt travel time
- Analysis of smolt survival
- Analysis of survival to adult
- Need for a risk assessment integrating empirical information and theoretical approach

Historic and Present Flow

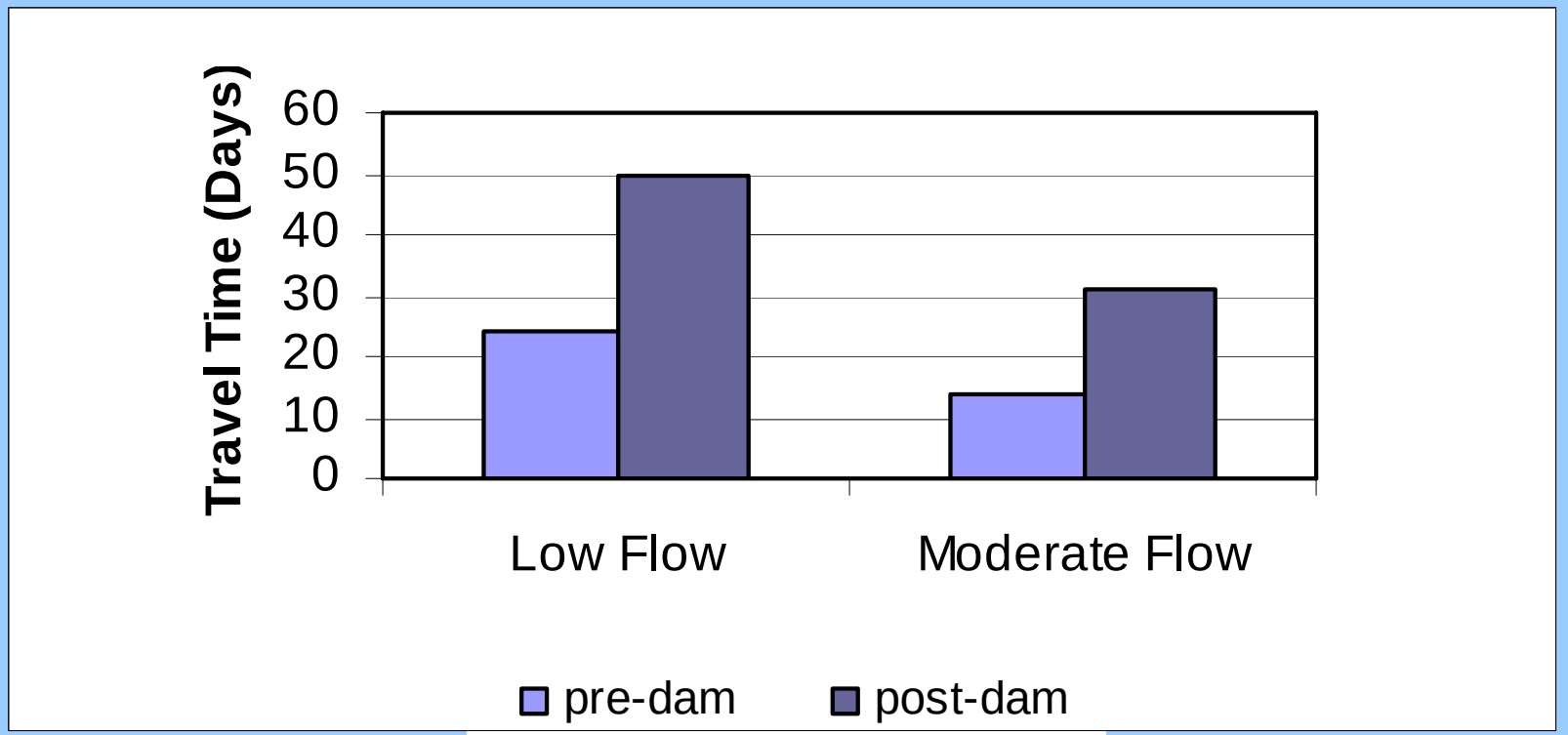


Historic Water Travel Times

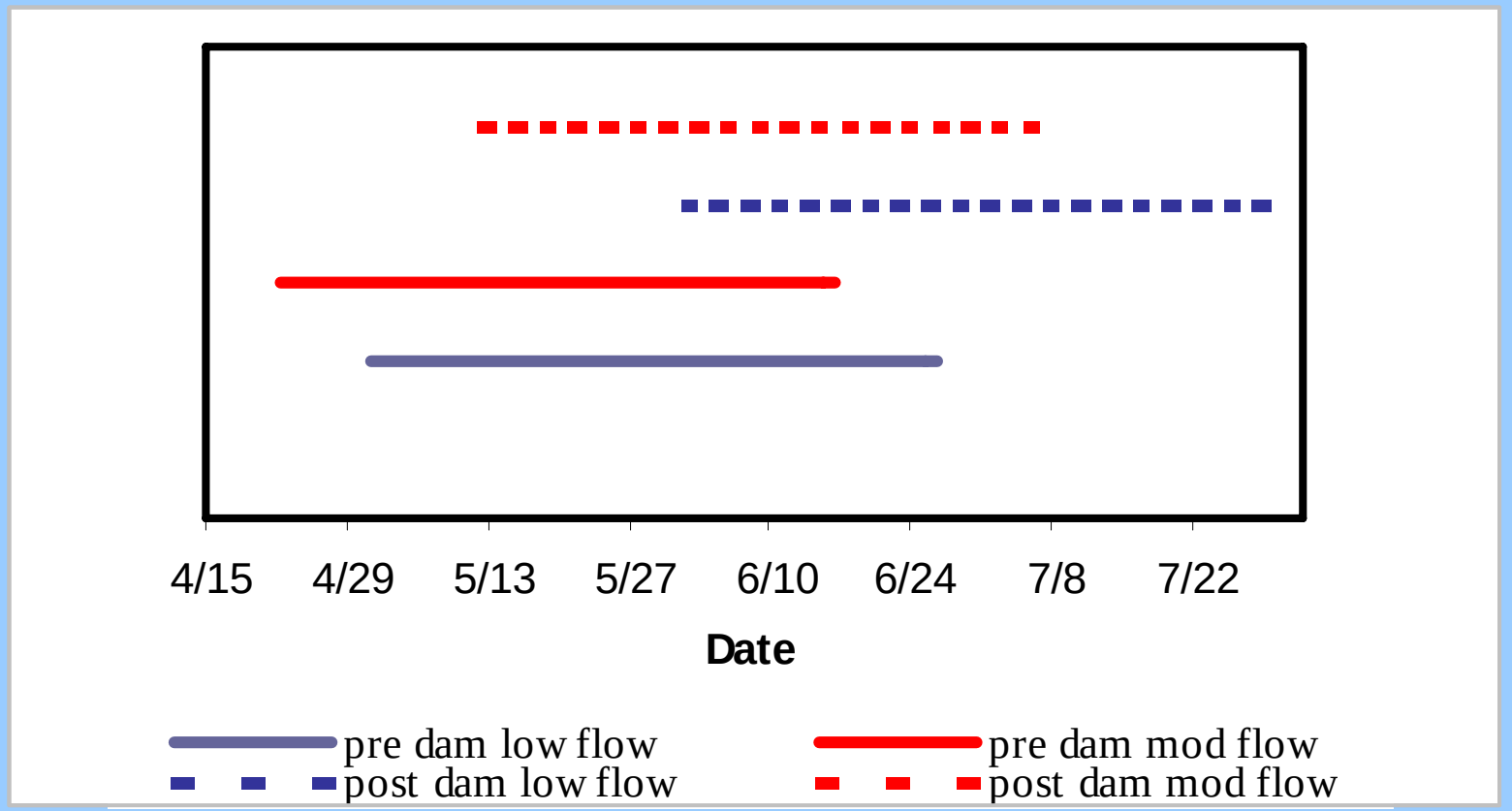


Estimated Travel Time for wild Chinook from the Salmon River to the Mouth of the Columbia River

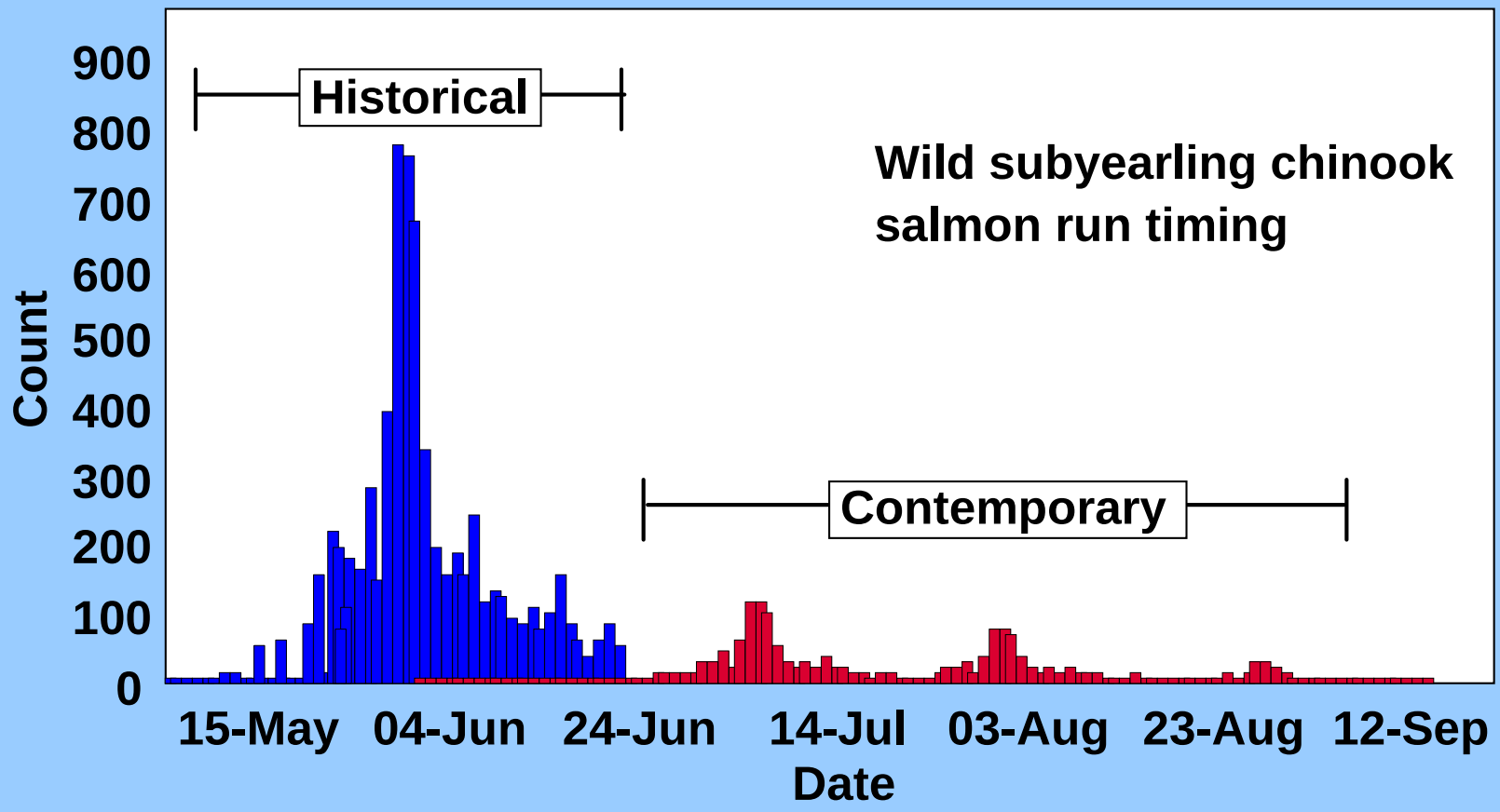
(derived from Raymond 1979)



Estimated Time of Salmon River Wild Chinook Entry into Seawater



Subyearling Chinook Historic Timing



Smolt migration: Why focus on flow?

- **Mechanisms:**

  Flow affects:

  - **Time to estuary;**
  - **Temperature exposure;**
  - **Energy reserves and stress;**
  - **Timing of salt-water entry;**
  - **Estuary plume.**

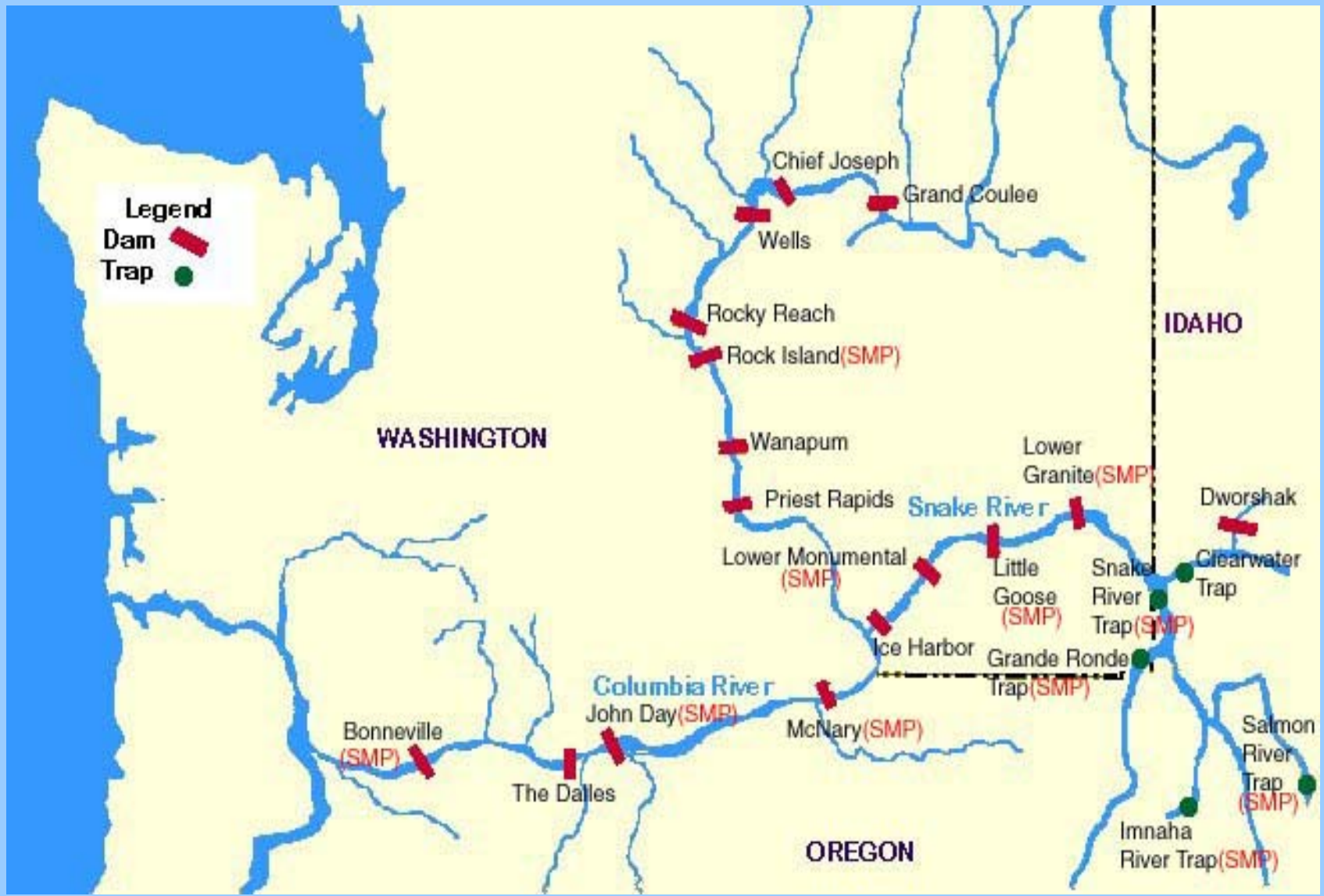
- **Measurements:**
  - **Travel Time**
  - **Direct mortality (estimated by inriver or reach survival)**
  - **Delayed mortality (related to fish condition, not observed directly)**

Travel Time

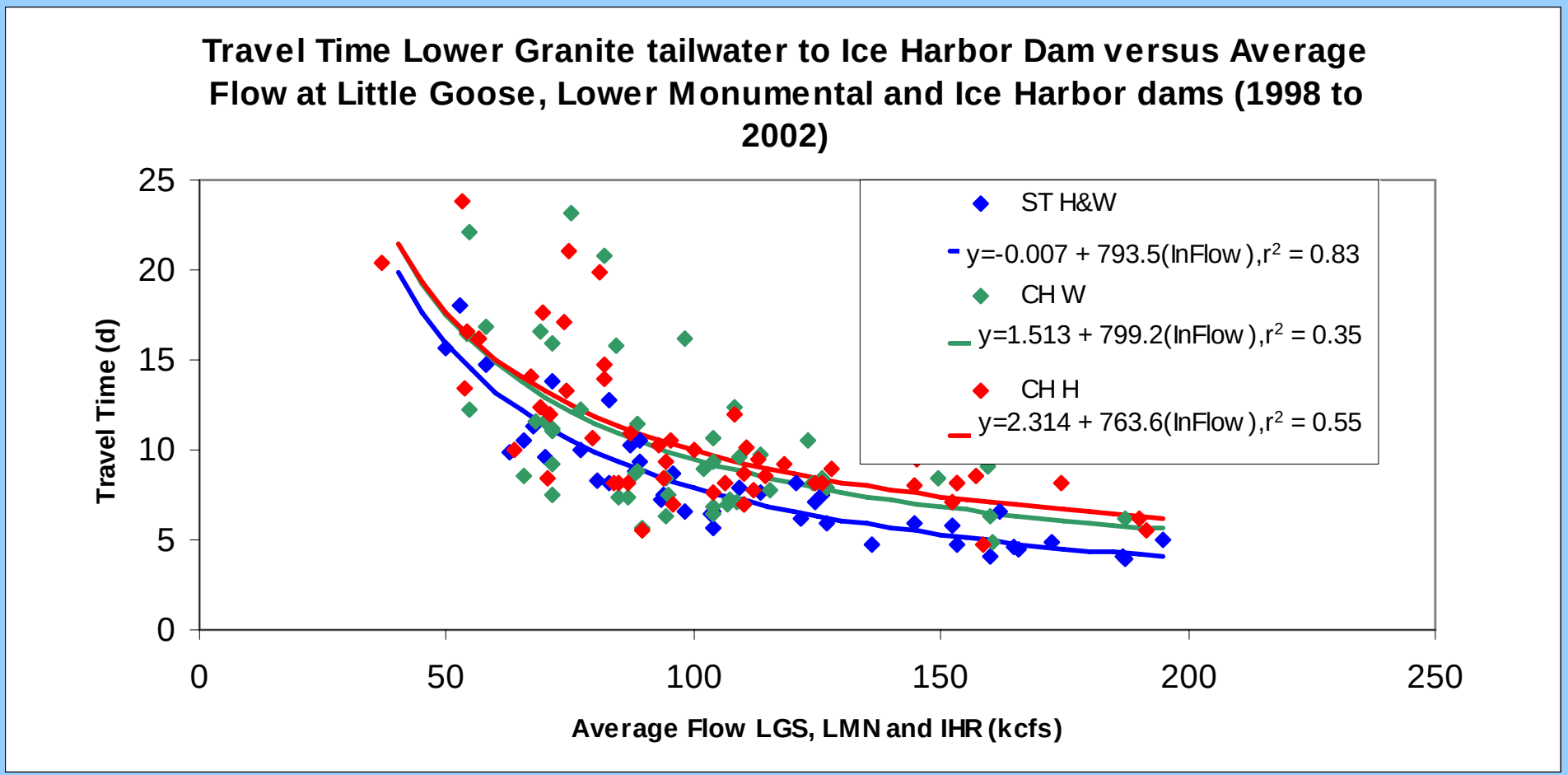
- Key characteristic reflecting the dynamics of migration
- Physiological condition changes over time and arrival at estuary within “biological window” determines successful transition to seawater.
  - Studies (Congleton 2000, 2001, 2002) showed juvenile salmonids in negative energy balance throughout downstream migration. Prolonged migration periods showed exhaustion of lipid reserves and greater use of protein reserves – muscle mass metabolized and activities of rate limiting enzymes involved in saltwater adaptation may be reduce.

Methods for Travel Time

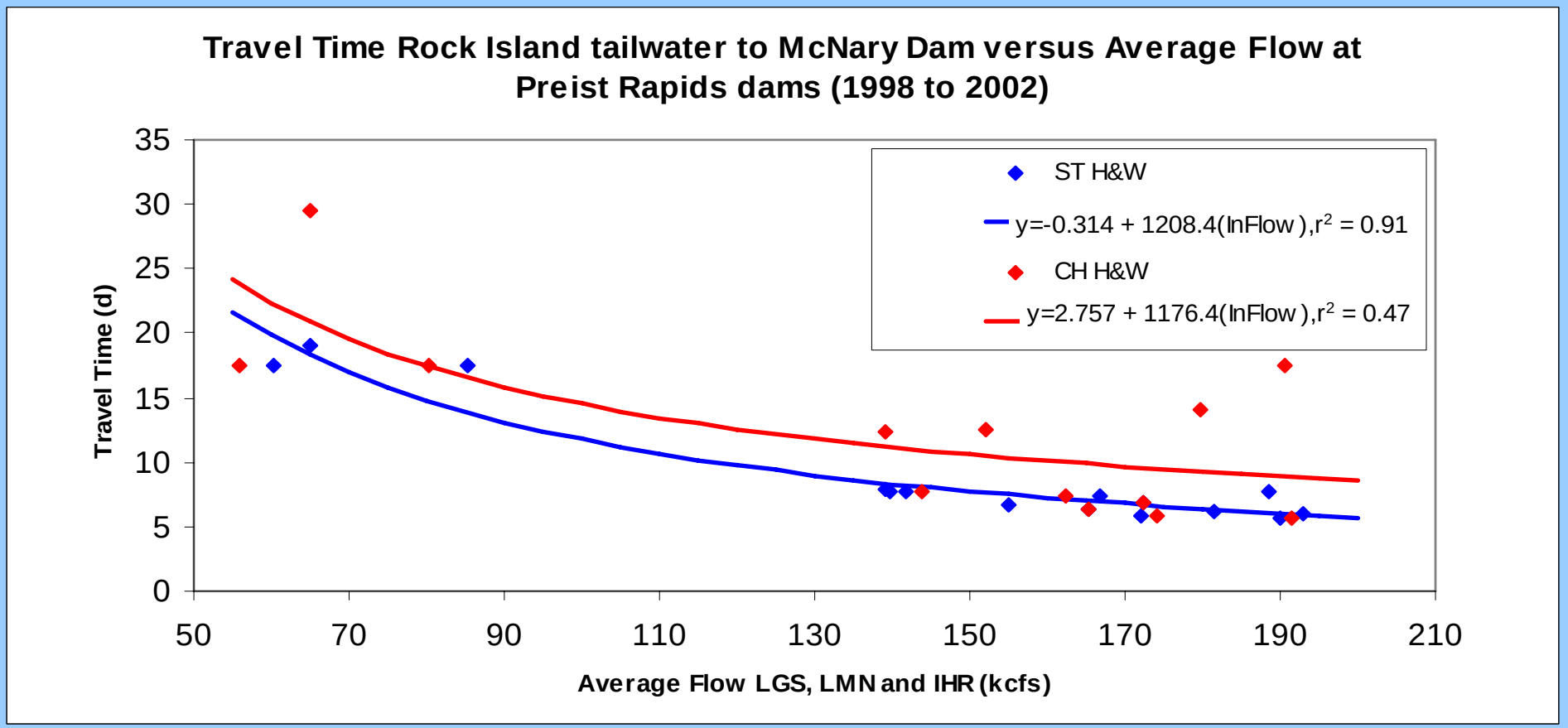
- Smolt travel time is defined as the amount of time needed for juvenile migrants to transit the river system between any two points.
- All data presented made use of PIT tag technology.
- Median travel time estimates were calculated for each temporal release block for the Lower Granite to McNary Dam Reach, Rock Island to McNary Dam Reach and McNary to Bonneville Dam Reach.


Legend
Dam
Trap
Chief Joseph
Grand Coulee
Wells
Rocky Reach
Rock Island(SMP)
IDAHO
WASHINGTON
Wanapum
Lower
Granite(SMP)
Priest Rapids
Snake River
Dworshak
Lower Monumental
(SMP)
Little
Goose
(SMP)
Snake
River
Trap(SMP)
Clearwater
Trap
Ice Harbor
Grande Ronde
Trap(SMP)
Columbia River
John Day(SMP)
McNary(SMP)
Bonneville
(SMP)
The Dalles
Salmon
River
Trap
(SMP)
Imnaha
River Trap(SMP)
OREGON

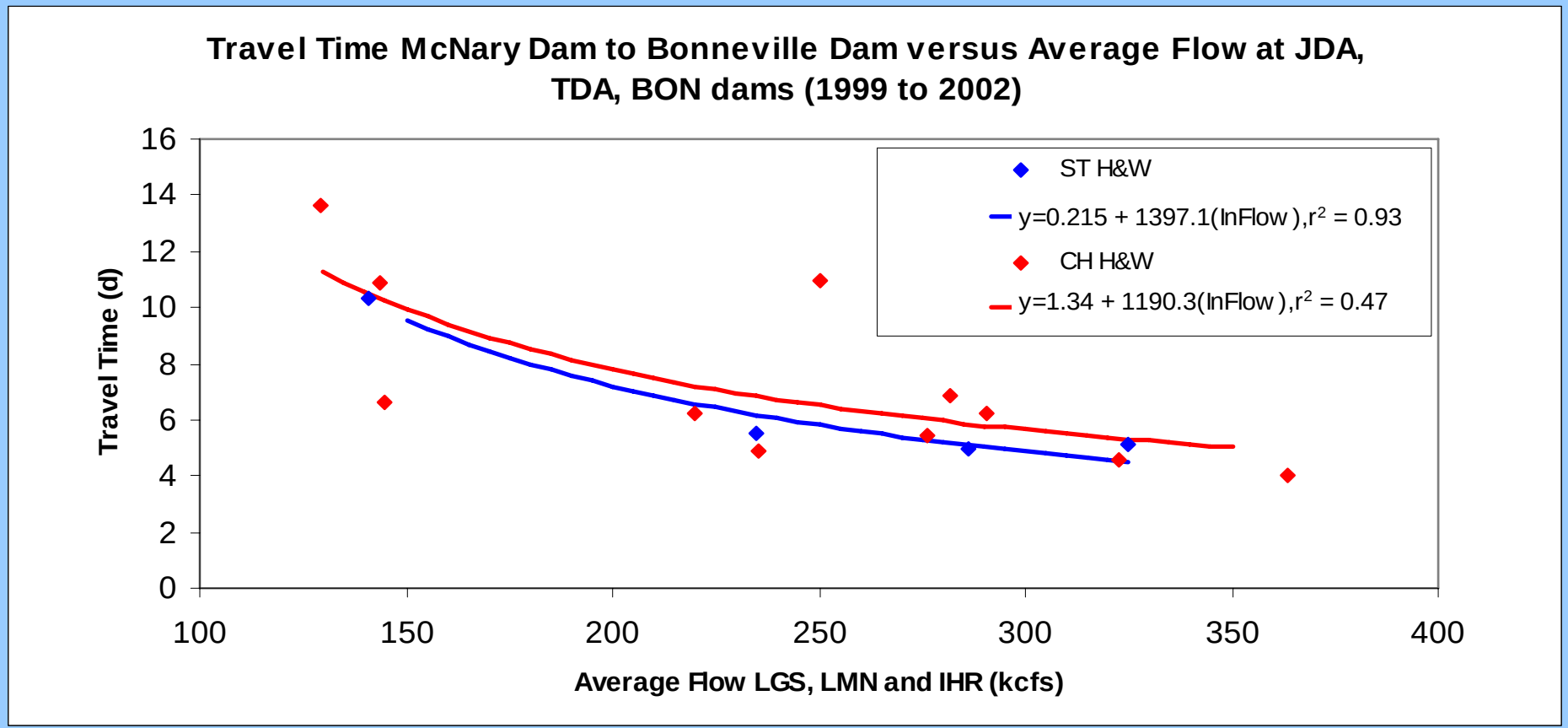
Snake River Travel Time vs. Flow



Mid Columbia River Travel Time vs. Flow



Lower Columbia Travel Time vs. Flow



Method for Reach Survival Estimates

- Survival estimated using Cormack-Jolly-Seber tag-recapture methodology.
- Time series limited by installation of PIT tag facilities (John Day 1998).
- Longest time series available for Snake River migrants (also has the greatest changes in variables of interest).
- Data collected for Mid Columbia and Lower Columbia confirms those relations observed in Snake.

Data Set Determination

- PIT Tag detection limits of earlier years necessitated extrapolation of survival estimates. Misrepresentation of survival estimates occurred when short reach data applied to longer reaches. Consequently, post 1998 considered in this analysis.
- Weekly blocks to decrease overlap of environmental variables.
- Temporal release blocks greater than 300 smolts to assure sufficient recoveries downstream.
- Estimate excluded when CV > 0.25 (SE/est).

Methods: Inseason vs. Across Season Survival Estimates

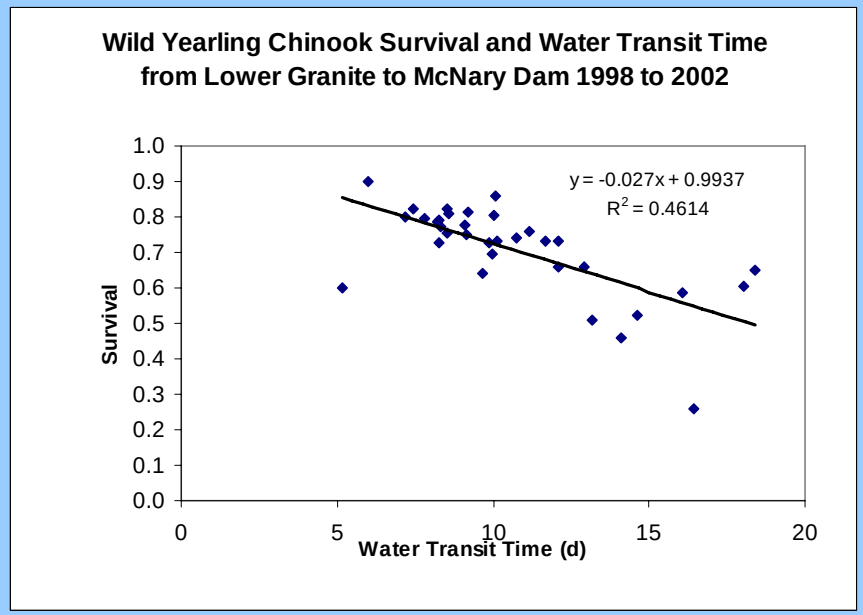
A within year flow survival relationship does not emerge in the present data, **not** because flow is not important but because:

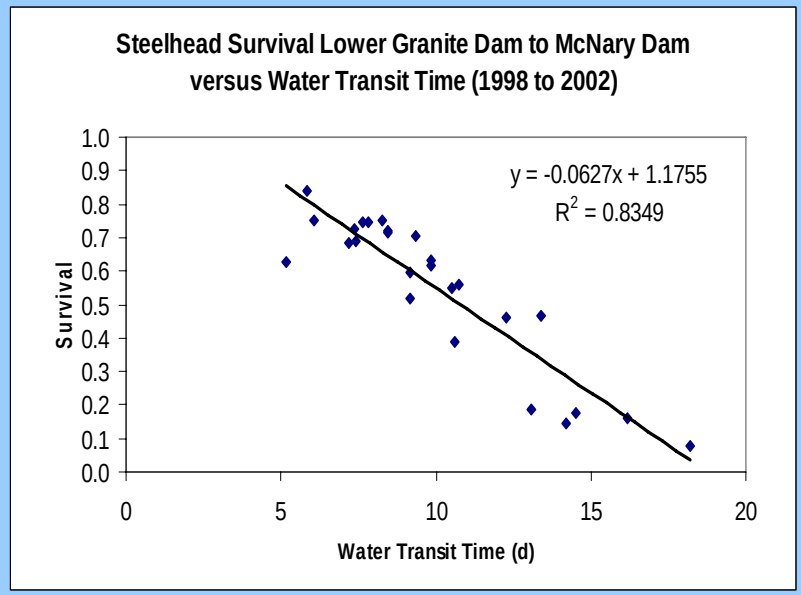
1. Juvenile survival is the result of many direct and indirect environmental and biotic variables described as averages over a period of time.
2. Individual survival release groups overlap and the environmental variables such as flow are averaged over many days and many overlapping release groups.
3. Annual estimates of survival address the problem of overlap to some degree, however, the annual flow average (even over large groups) had not changed substantially until 2001, when the Biological Opinion measures were not implemented.

Environmental Variables for Spring Migrants

- Water Transit time
  - Flow variable quantified as the summation of water transit times for each reservoir incorporated in a reach.
- Spill Proportion
  - daily Spill/Total discharge averaged over a seven day median passage window for each species and project.
- Water Temperature
  - averages of river temperature developed for 7 day blocks around the median dates of passage.

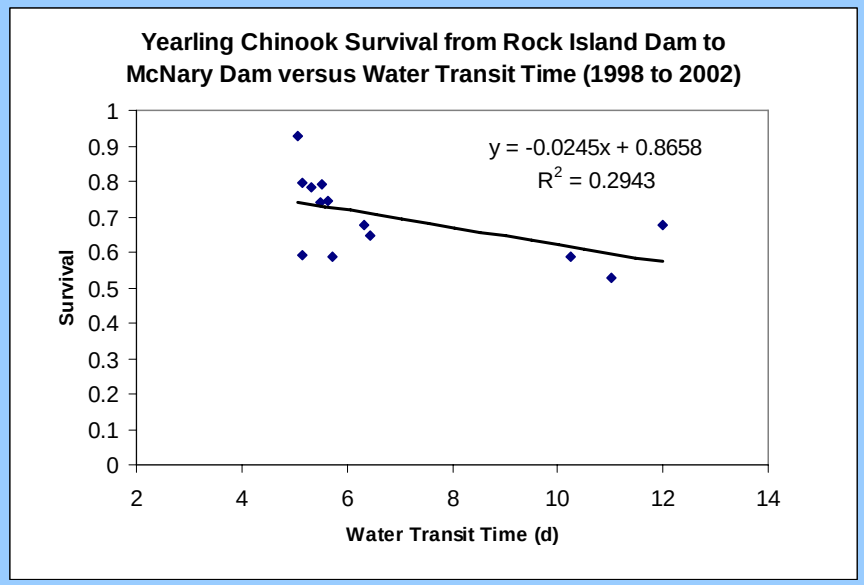
Snake River Water Transit Time versus Survival

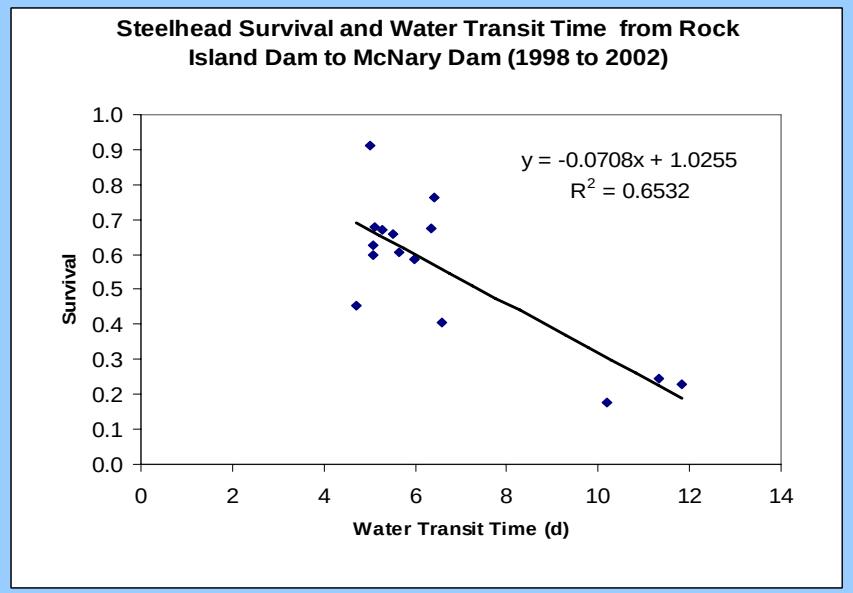




Species	N	Variable	Coefficient	SE	P	MSE	R^2
Chinook	66	Constant	1.09264	0.13901	0.00000	0.0586	0.65
		WTT	-0.01497	0.00504	0.0042		
		SPILLPROP	0.00281	0.00106	0.01027		
		TEMP	-0.02624	0.00765	0.00109		
Steelhead	26	Constant	0.79901	0.13203	0.00000	0.00639	0.87
		WTT	-0.04184	0.00831	0.00004		
		SPILLPROP	0.00527	0.00117	0.00508		

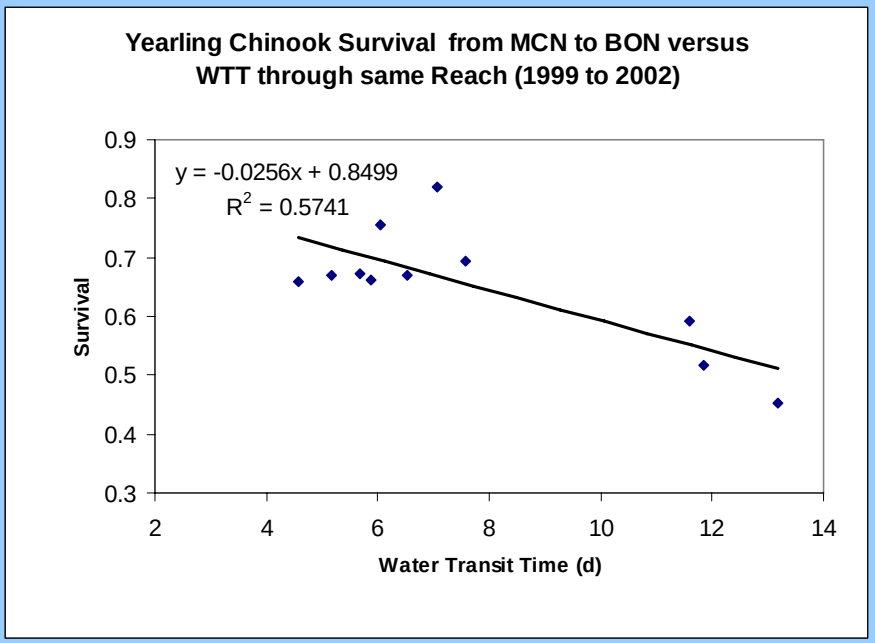
Mid Columbia River Water Transit Time versus Survival

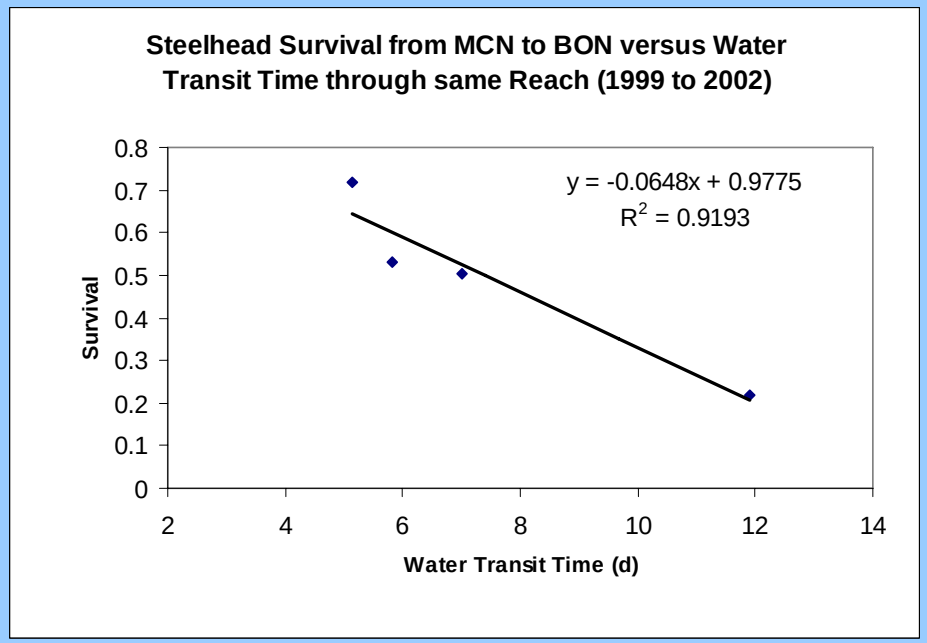




Species	N	Variable	Coefficient	SE	P	MSE	R^2
Chinook	13	Constant	0.8659	0.08282	0.00000	0.00956	0.29
		WTT	-0.02446	0.54250	0.05543		
Steelhead	15	Constant	1.6135	0.2425	0.00002	0.01136	0.74
		WTT	-0.06065	0.01256	0.00041		
		TEMP	-0.0553	0.02138	0.02383		

Lower Columbia Water Transit Time vs. Survival

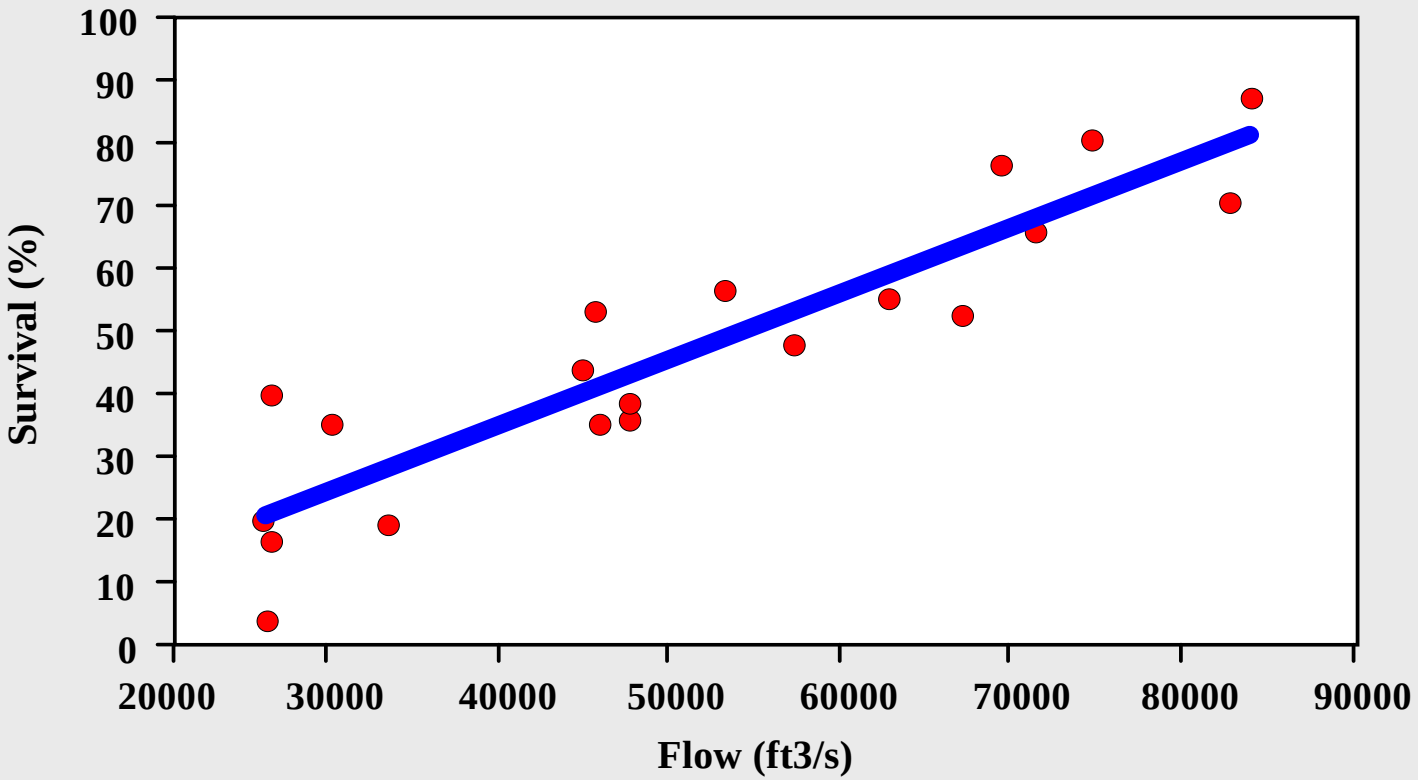




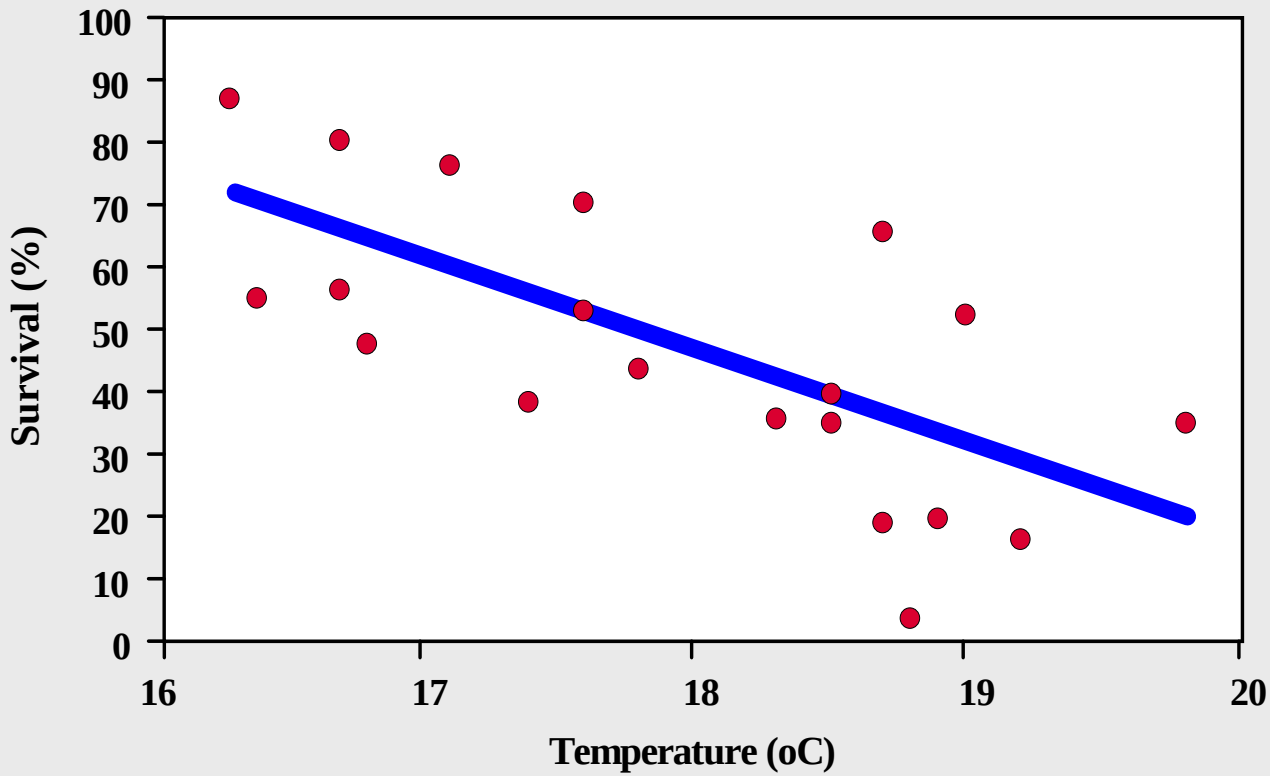
Species	N	Variable	Coefficient	SE	P	MSE	R^2
Chinook	11	Constant	0.8499	0.05856	0.00000	0.00455	0.57
		WTT	-.0256	0.00709	0.00543		
Steelhead	4	Constant	0.97747	0.10775	0.0119	0.00518	0.92
		WTT	-0.06481	0.01358	0.0412		

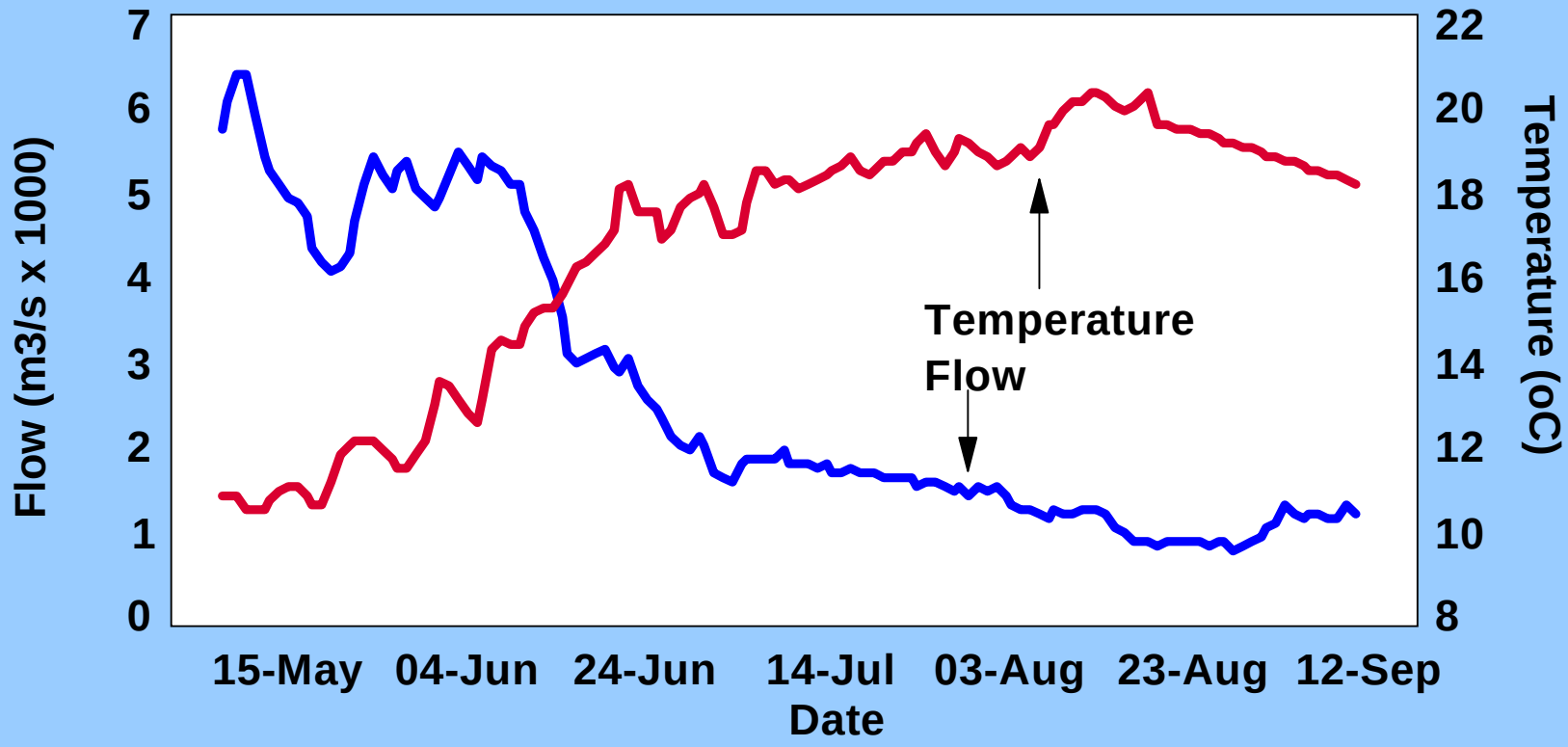
Subyearling Flow vs Survival

Survival of wild subyearling fall chinook salmon to Lower Granite Dam Tailrace versus flow, 1998-2002.



Survival of wild subyearling fall chinook salmon to Lower Granite Dam Tailrace versus Temperature, 1998-2002.




Flow (m3/s x 1000)
7
6
5
4
3
2
1
0
22
20
18
16
14
12
10
8
Temperature (oC)
Temperature
Flow
15-May
04-Jun
24-Jun
14-Jul
03-Aug
23-Aug
12-Sep
Date

New or Additional Information on Summer Migrants

- NOAA Presentation For Lower Columbia River subyearling migrants, 1999-2002.

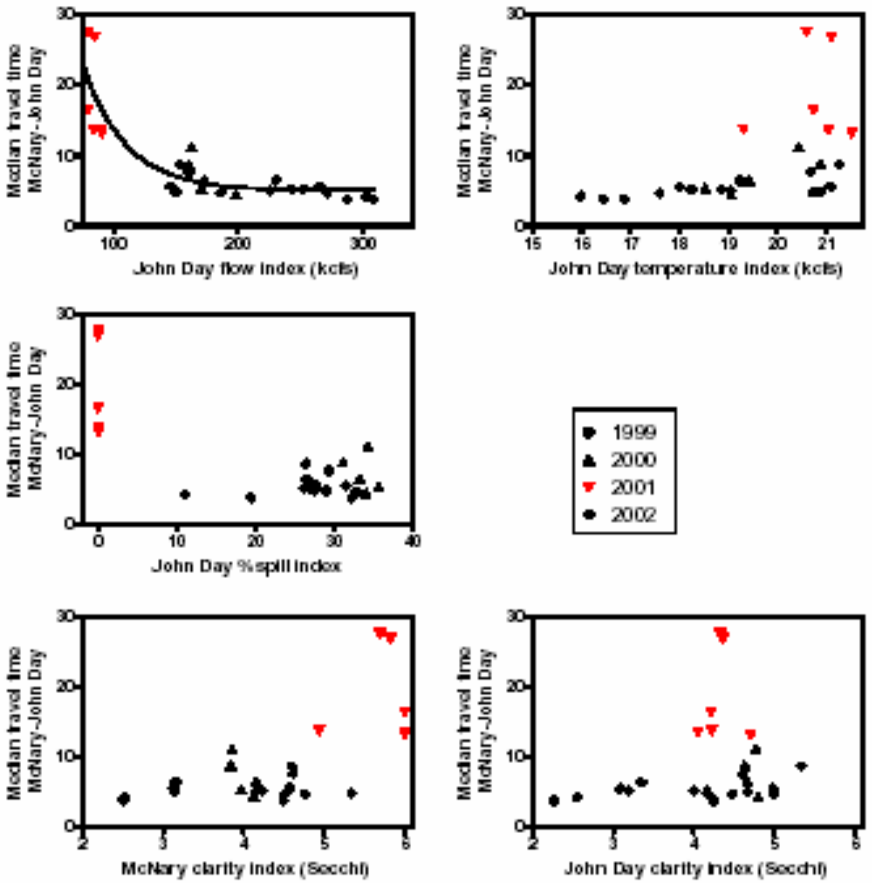
- FPC Rock Island to McNary Dam subyearling migrants,

Lower Columbia River

- Run-of-river collected & tagged at McNary Dam
- Mostly Hanford Reach; a few hatchery
- Weekly pooled groups
- Survival and travel time between McNary and John Day Dams
- “Exposure index” based on McNary dates and John Day passage timing (mean during release and during middle 50% of passage, respectively)
- 1999-2002, typically 19 June – 30 July

NWPCC Symposium
9 November 2004

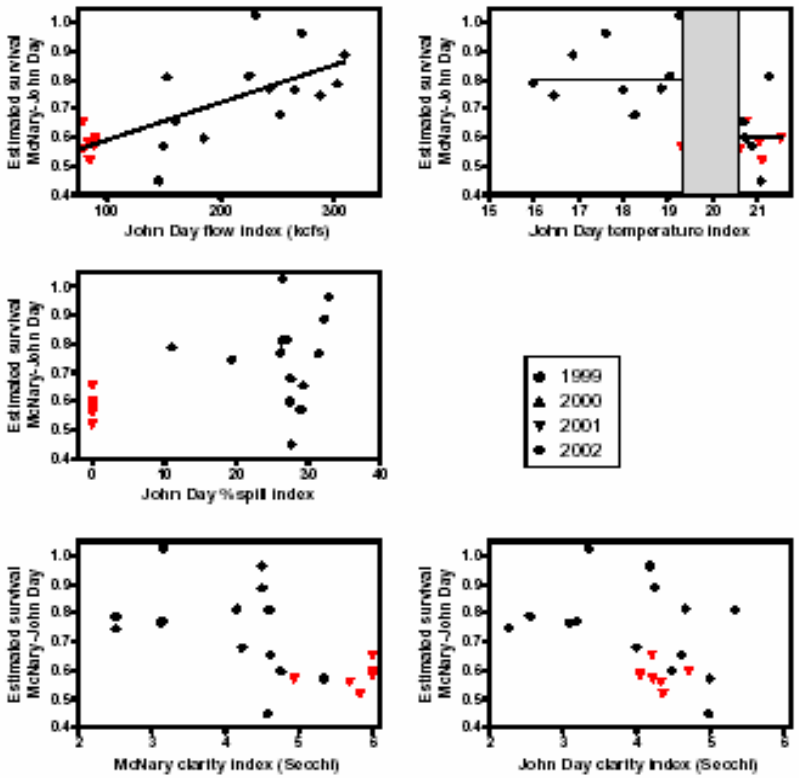
Lower Columbia River



Median travel time vs. river conditions 1999-2002

Figure 48. Median travel time between McNary and John Day Dams plotted against various river condition indices for run-of-river subyearling Chinook salmon released in the tailrace of McNary Dam, 1999–2002. Flow index panel illustrates exponential-decay curve fit to data.

Lower Columbia River



Estim. survival vs. river conditions 1999, 2001, 2002

Figure 49. Estimated survival between McNary Dam tailrace and John Day Dam tailrace plotted against various river condition indices for run-of-river subyearling Chinook salmon released in tailrace of McNary Dam, 1999, 2001, and 2002. Flow index panel illustrates simple linear regression line without year effects. Temperature index panel illustrates constant mean survival above and below 20°C.

Lower Columbia River Conclusions

- Definitive conclusions are not possible:
  – Sparse, highly variable data
  – Can't discern effects of conditions from
  generalized year effects

Lower Columbia River Conclusions

Tentative conclusions (Tech. Memo.):

- Travel time likely depended on water velocity
- Flow had larger incremental effect at low flows

  than at high
- Travel time may affect survival (predation)
- Possible threshold temperature around 20^{o}

FPC Analysis

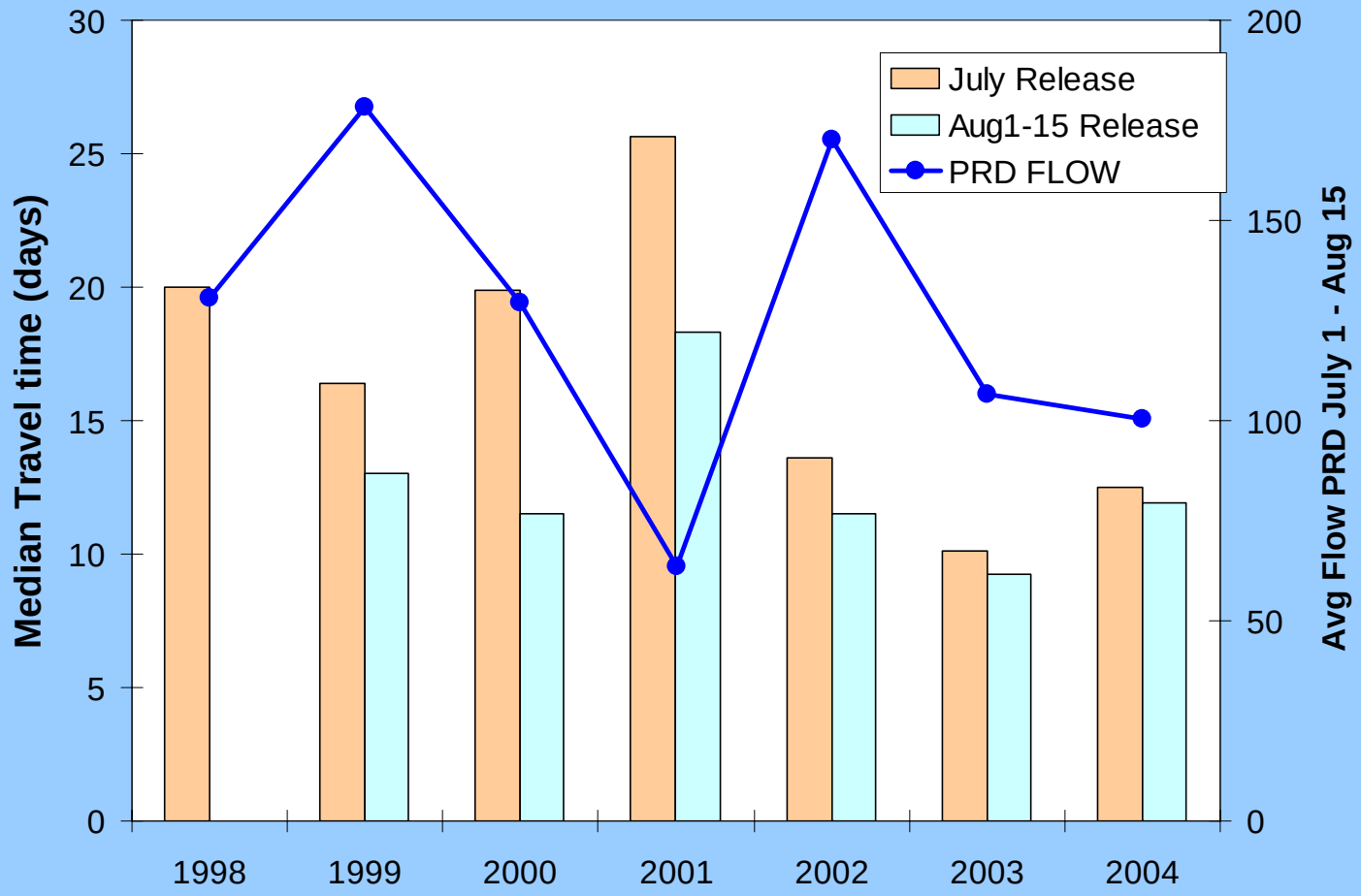
- Data on subyearling chinook (Ch0) PIT tagged and released at Rock Island Dam for the FPC's Smolt Monitoring Program.

Topics of Discussion

- August flows indexed at MCN
- Travel time of PIT tagged Ch0 from MCN to BON in July and August
- Travel time of PIT tagged Ch0 released at RIS to MCN
- Reach survival of PIT tagged Ch0 released at RIS to MCN tailrace.
- Reach survival versus flow relation

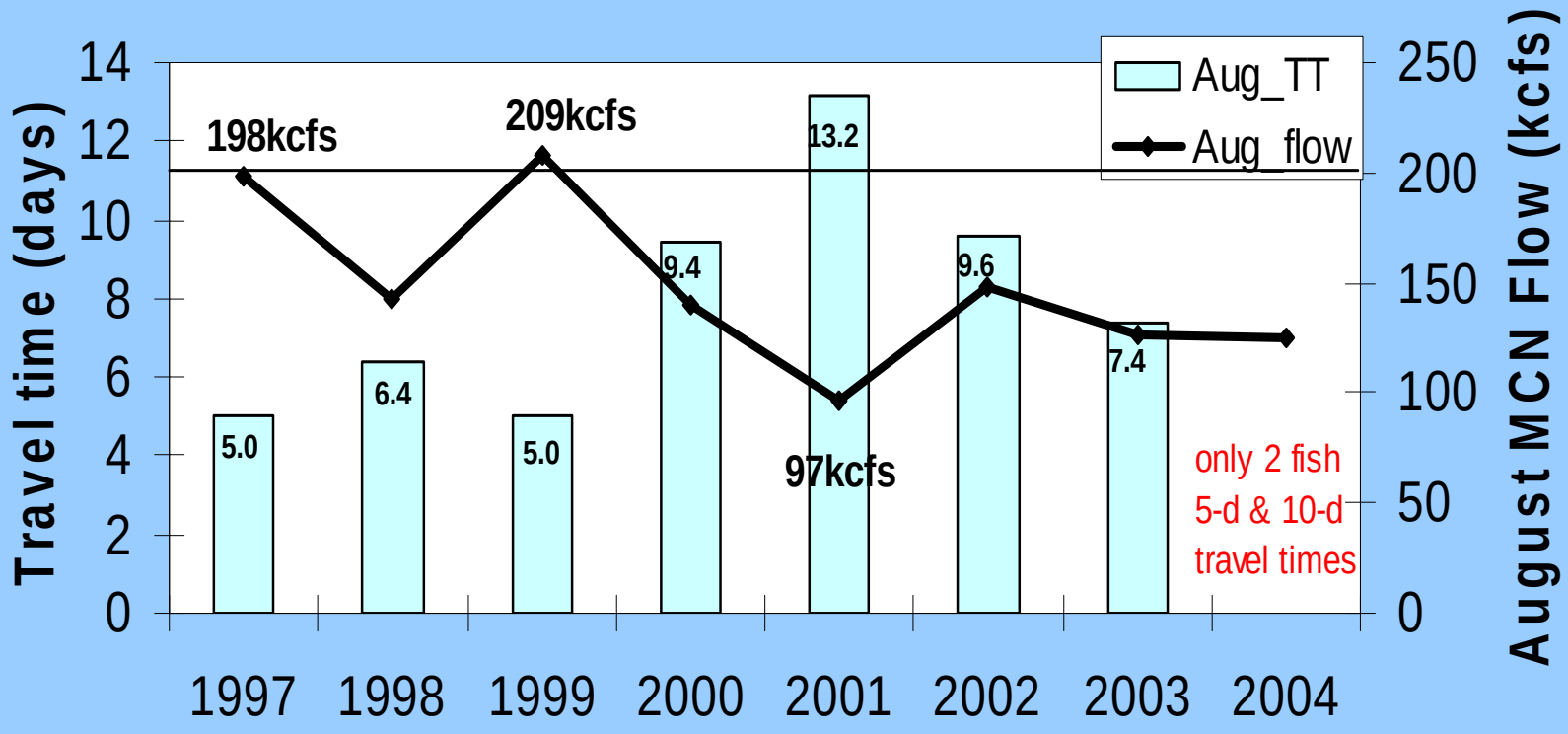
Ch0 Travel Time RIS to MCN

Longest TT in 2001 -- shortest TT in 2003



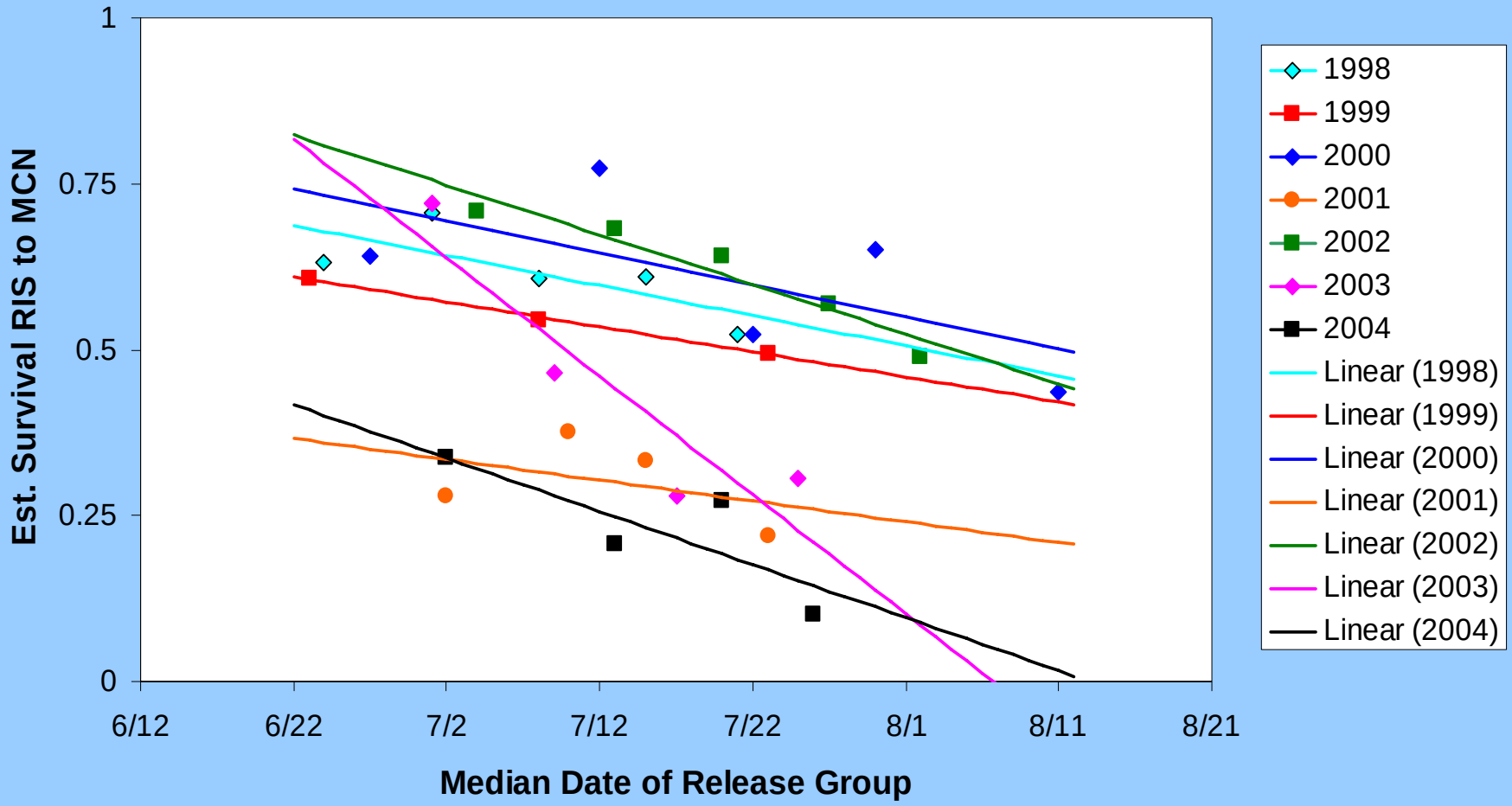
Ch0 Travel time MCN to BON

Reach BIOP 200 kcfs in 1997&99 -- fastest TT



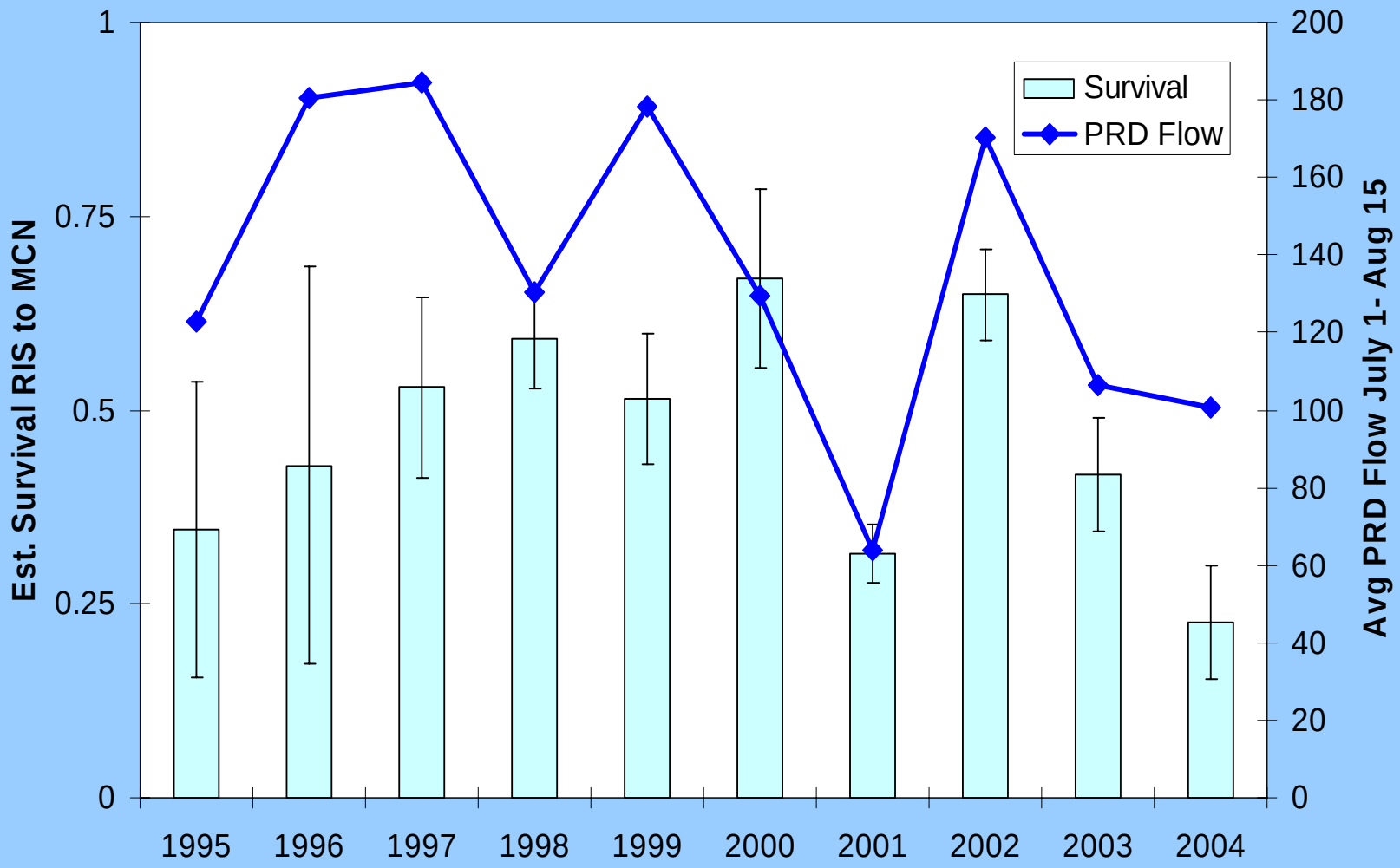
Ch0 Mortality higher August

Survival drops over season in all years,
but worse impact in lower flow years



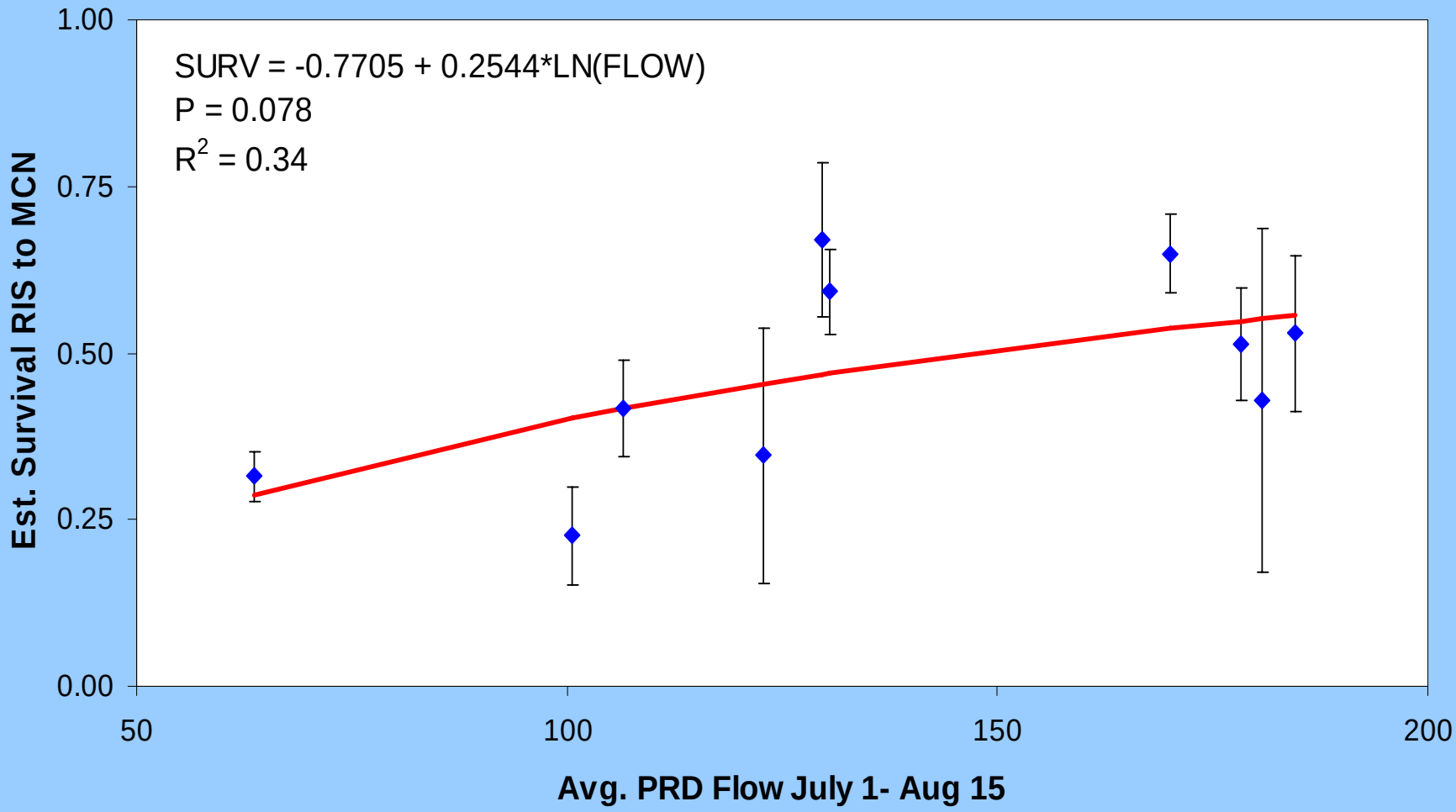
Ch0 Survival RIS-MCN

July releases: higher survival with higher flows



Ch0 Survival to Flow Relation

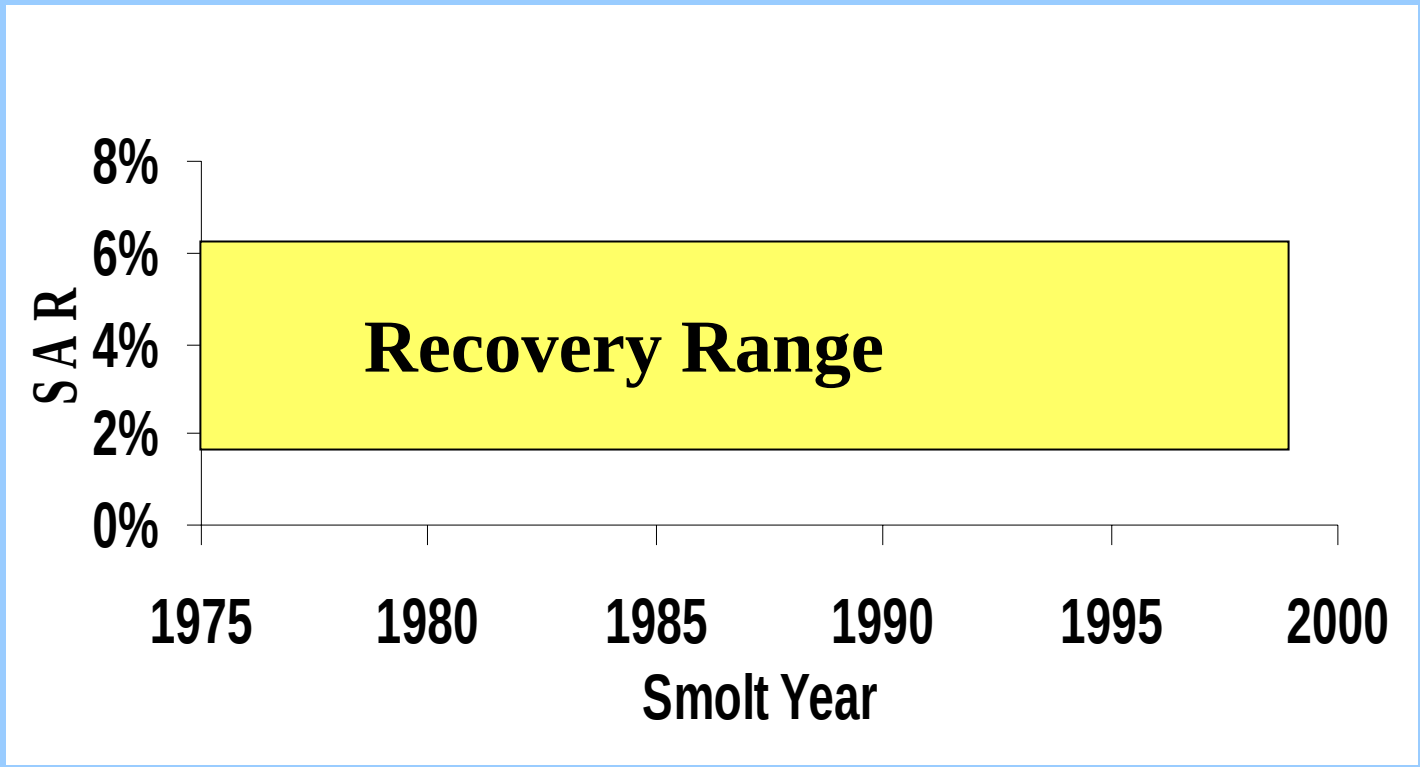
July releases RIS to MCN survival rates increase with flow



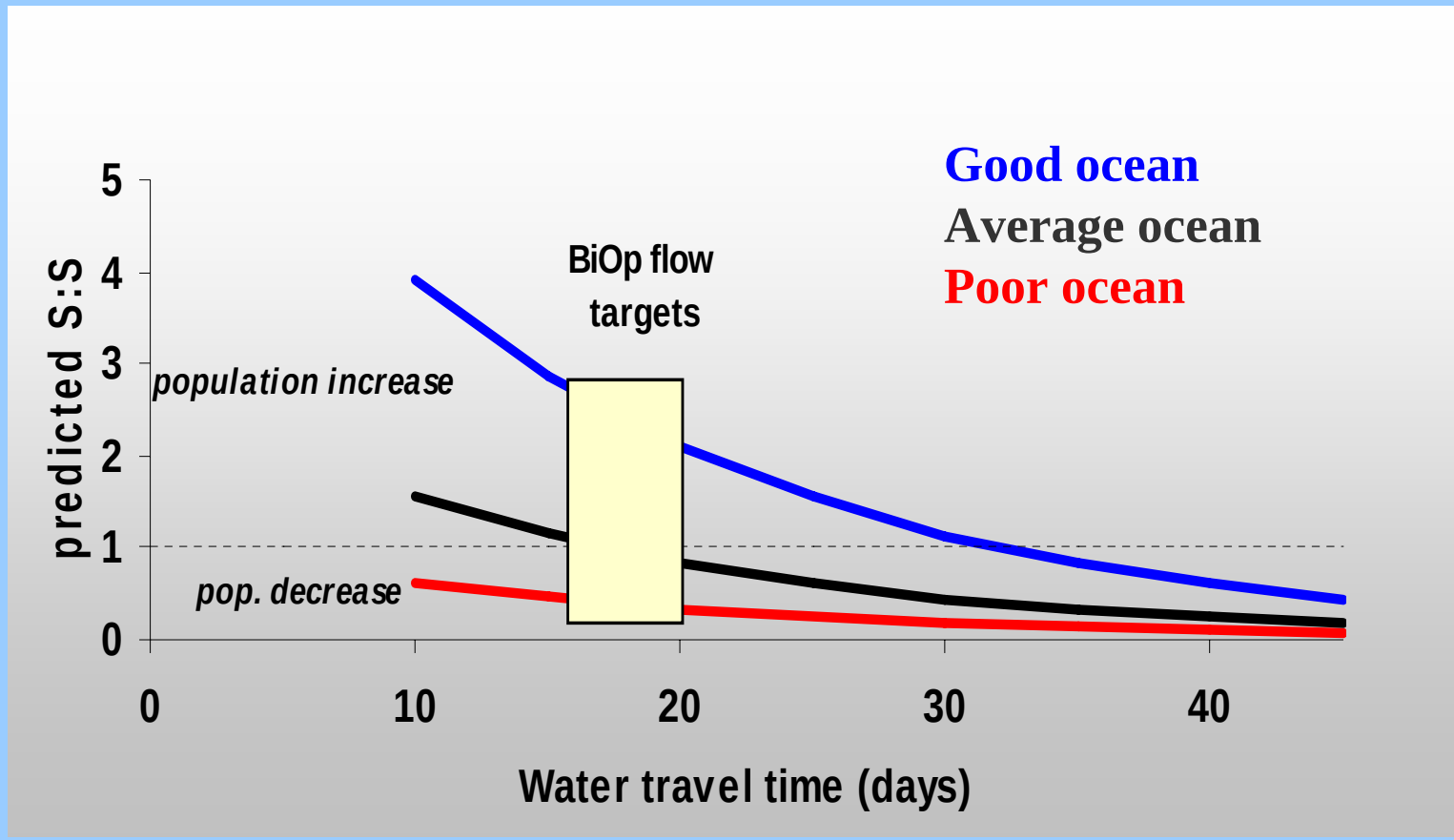
Juvenile Summary

- All data collected and analyzed to-date shows flow as the important factor affecting the overall survival of juvenile migrants transiting the hydroelectric power system.
- Flow affects the migration timing and ocean entry.
- Small incremental changes in flow volumes are difficult to quantify for fish survival.
- However, all data collected suggests that decreasing flows increases the risk to the already high risk populations.

Smolt to Adult Survival Rate (SAR)
Interim objective = 2-6%



Influence of Water Travel Time and Ocean Effect on Spring/Summer Chinook S/S (predicted)



Snake R. spring/summer chinook

Risk Assessment: Integrating empirical & theoretical information

- The steps for assessing hypotheses about the effect of Columbia River hydrosystem on salmon and steelhead survival, growth, behavior and physiology:
  - formally describe hypothesized linkages between management and environmental causes and effects, and to organize evidence for and against these linkages
    - the **clarity of the hypothesis**;
    - existence of a reasonable mechanism(s) by which the hypothesis operates;
    - **consistency with empirical evidence**;
    - **validity of the method of projecting the hypothesis into the future**
  - Weight of Evidence" process to systematically and objectively assess the strength of evidence for and against hypothesized mechanisms
  - Incorporate into a formal decision analysis for evaluating management alternatives

Conclusion

- Believe multiple lines of evidence show flow /survival relationship
- Need to consider large scale climate/ocean conditions.
- Given BIOP flow targets stocks are still at risk (average-poor climate/ocean conditions).
- Any degradation in flows will place stocks at higher risk